Final Report (pr-5)

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OPAD Plume Anomaly Detector Study

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Quantitative Description Of Work Performed This Period

- This investigator attended a technical planning meeting with personnel from EB22 labs at MSFC, NASA Ames, and summer faculty research staff. In addition to working with the codes, we briefed the summer faculty, and planned our tasks for supporting the X33 and engines to be fired at the TTB as well as Arnold Engineering & Development Center (AEDC).
- This investigator attended a concept design review at AEDC intended to define goals for in-flight versions of OPAD technologies based upon resonance absorption of selected atomic transitions at the exhaust plume exit plane and emission measurements for analyses during startup and low altitude flight.
- Although significant quantitative and qualitative evaluation and validation of Spectra6 occurred last activity period regarding the Stennis engine failure data, efforts continue to focus on better methods of dealing with the unknowns related to the chemical depletion and reaction completion questions associated with dissociation of metal-molecules bonds upon crossing the shock. The chemical depletion rates issue is also similar importance relating to the absorption at the exit plane, due to freezing of the chemistry, thus producing non-equilibrium in the number density distribution among the atomic (molecular) states .
- A first-draft implementation of the partial differential multivariable analyses code is near completion and is based upon the development version of spectra. This method will also lend itself to the absorption version of spectra. These tools will allow determination of the code errors propagations as well as enhance the selection process by which certain spectral regions are chosen in both emission and absorption.
- The problem has been formulated as in the following

  $dI = \left.\frac{\partial I}{\partial \beta_k}\right|_{\beta_{k0}} d\beta_k$, where β's represent the following variables {number densities, broadening parameters, plume temperature, response function fwhm, etc} and repeated indices imply summation. Evaluation of the above at a point $\{\beta_k\}_0$ in this N-dimensional space will allow a computation solution for $\frac{dI}{d\beta_k}$.

- A final version of the atomic spectral code has been deposited at *cooper.msfc.nasa.gov* for use by EB22 and research personnel.
- This report is late in part due to requirements necessary to comply with guidelines to acquire copyrights to the spectral code discussed in the five progress reports under this contract. Application for copyright permission has now been submitted to the Contracting Officer and the Director of New Technology.

Problems Found/ Solutions

- Significant computational speed will be required for the full blown partial differential multivariable analyses code. This function basically must run the code over an extremely broad range of N - dimensional variable space in order to compute the partial derivatives. A simplified version may suffice in some cases.

Indication Of Problems Which May Impede Work Performance, Schedule And Suggested Course For Correction Of Problems

- Neural Network predictions from UA are still problematic in terms of dealing with the wavelength variations in the spectral calibration; further development may provide an important first guess for the fitting routines that will significantly speed up convergences.
- Any opportunities to seed a production engine will become paramount to the success of producing accurate data. Seeding data will also be required from the next engines to be fitted with OPAD technology in order to maintain the same level of uncertainty in predicted values of mass loss rates.

Cumulative Cost Analysis

(a) Total cumulative costs to date	**$24,000.00**
(b) Estimate of cost to complete contract	**$0.00**
(c)Estimated percentage of physical completion	**100.0 %**

(d) Statement of cumulative costs versus physical completion:
Cumulative costs are consistent and in agreement with physical completion and no significant variance is observed.

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13. ABSTARCT (Maximum 200 words)

The development of an analytical-numerical model to predict radiant emission or absorption is discussed herein. A voigt profile is assumed to predict the spectral qualities of a singlet atomic transition line for atomic species of interest to the OPAD program. The present state of this model is described in each progress report required under contract. Model and code development is guided by experimental data where available. When completed, the model will be used to provide estimates of specie erosion rates from spectral data collected from rocket exhaust plumes or othersources.

Emphasis is placed upon recent efforts to evaluate and validate Spectra6/NN

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